CSSL-IV Program Listing

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PROGRAM ADEM
" Lead Acid Battery Model "
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" Program Consultant: Dr. Yilmaz Sahinkaya, Phone:(650) 574-0254 "
" SMA, Inc., San Jose, CA "
" Model Creation Date: April 5, 2000 "
                      " Units : Metric "
                      " System Parameters "
" General Parameters"
" TFIN  = Simulation Time (Sec) "
CONSTANT TFIN  = 390.0
" TSCELL= Starting Time (Sec) "
CONSTANT TSCELL= 1.0
" Lead Acid Battery Parameters "
" Electric Analog Circuit Parameters "
" Control Parameters "
" IBB14   = Battery Current Command (Amperes(Amps) vs Time(sec)"
" IMODB14 = Type of Battery Current Input "
" IMODB14 = 0.0 Means IBB14 is defined by IBB14T (Cycling Test)"
" IMODB14 = 1.0 Means IBB14 is defined by IBB14IN (Discharge Test)"
CONSTANT IMODB14 = 0.0
   TABLE IBB14T, 1, 18,...
   0.0, 0.005, 30.0, 30.005, 60.0, 60.005, 120.0, 120.005, 210.0,...
   210.005, 240.0, 240.005, 300.0, 300.005, 360.0,...
   360.005, 389.995, 390.0,...
   0.0,-50.0,-50.0, 0.0, 0.0, 5.0, 5.0,-30.0,-30.0,...
   50.0, 50.0, 0.0, 0.0, -15.0, -15.0,...
   25.0, 25.0, 0.0
CONSTANT IBPER14 = 390.0    $" Battery Cycling Current Period (Sec)"
CONSTANT IBB14IN =   0.0    $" Discharge Current Step (Amp) "
" RICnB14  = Cell-n Internal Resistance (Ohms) "
" RLCnB14  = Cell-n Leakage Resistance (Ohms) "
" All RIC's and RLC's vary with TIB14 = Interior Battery Temperature "
" TIB14  = Interior Battery Temperature (Deg C) "
" CFRB14T= Temperature Correction Factor for Cell RI's and RL's "
" Initial Cell Resistance Values in Ohms at 25 Deg C "
CONSTANT RIC6B14I = 0.005, RLC6B14I = 750.0    $" 6 th Cell "
CONSTANT RIC5B14I = 0.005, RLC5B14I = 750.0    $" 5 th Cell "
CONSTANT RIC4B14I = 0.005, RLC4B14I = 750.0    $" 4 th Cell "
CONSTANT RIC3B14I = 0.005, RLC3B14I = 750.0    $" 3 rd Cell "
CONSTANT RIC2B14I = 0.005, RLC2B14I = 750.0    $" 2 nd Cell "
CONSTANT RIC1B14I = 0.005, RLC1B14I = 750.0    $" 1 st Cell "
TABLE CFRB14T, 1, 7,...
-45.0, -29.0, -18.0, 0.0, 25.0, 52.0, 75.0,...
 3.0, 3.0, 2.0, 1.2, 1.0, 1.0, 1.0
" CSB14, CSLB14  = Electrical Storage Capacitances(Farad) "
" VCMNB14, VCMXB14 = Minimum and Maximum Cell Voltage Limits (Volt)"
CONSTANT VCMNB14 = 1.9, VCMXB14 = 2.45
" CSB14 Varies with Battery Current (IBB14) within Voltage Limits "
TABLE CSB14T, 1, 11,...
-100.0,-50.0,-25.0,-15.0,-3.45, 0.0, 3.45, 15.0, 25.0, 50.0, 100.0,..
12.5E+5, 12.5E+5, 12.5E+5, 10.0E+5, 10.0E+5, 5.0E+5, 2.5E+5,...
2.25E+5, 2.5E+5, 1.5E+5, 1.5E+5
" CSLB14 Varies with Battery Current (IBB14) outside Voltage Limits "
TABLE CSLB14T, 1, 11,...
-100.0,-50.0,-25.0,-15.0,-3.45, 0.0, 3.45, 15.0, 25.0, 50.0, 100.0,..
 1.25E+5, 1.25E+5, 1.25E+5, 1.0E+5, 1.0E+5, 0.5E+5, 0.05E+5,...
 0.05E+5 , 0.1E+5, 0.05E+5, 0.05E+5
" Initial Values of State Variables "
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CONSTANT AHB14Z   = 69.0      $" Initial Battery AH Capacity "
CONSTANT AHB14R   = 69.0      $" Battery AH Rating "
" Cell Open-Circuit Voltages (Volts) "
CONSTANT VOC6B14Z = 2.15, VOC5B14Z = 2.15, VOC4B14Z = 2.15
CONSTANT VOC3B14Z = 2.15, VOC2B14Z = 2.15, VOC1B14Z = 2.15
" Cell Capacitance Selection Macro Definition "
" CCB14 = Cell Capacitance Selection Macro Name "
MACRO PMACRO CCB14, P
IF(P(3).LE.P(2).AND.P(2).LE.P(4))     THEN
      P(1)  =  P(5)
ELSEIF(P(2).LT.P(3).OR.P(2).GT.P(4)) THEN
      P(1)  =  P(6)
ENDIF
MACRO END
" Cell State Equations Computation Macro "
" CEQSB14 = Cell Equations Computation Macro Name "
MACRO MACRO CEQSB14, P
P(2)  = P(5)-P(6)
P(3)  = (1.0/P(7))*P(2)
P(1)  = INTEG(P(3), P(8))
P(4)  = P(9)*P(5)**2+P(10)*P(6)**2
MACRO END
" Thermal Model Parameters "
" MACID = Acid Mass (kg), CPACID = Specific Heat (Joules/kg-deg C) "
CONSTANT MACID  = 5.73 , CPACID = 2.11E+3
" MLEAD = Lead Mass (kg), CPLEAD = Specific Heat (Joules/kg-deg C) "
CONSTANT MLEAD  = 9.67 , CPLEAD = 128.0
" Battery Plastic Can Parameters "
CONSTANT THKB14 = 3.0         $" Thickness(mm) "
CONSTANT KSB14  = 1.903E-4    $" Conductance Coefficient(Watts/mm-deg C
CONSTANT ASB14  = 3.548E+5    $" Surface Area (mm**2) "
" MSB14 = Surface Mass (kg) "
CONSTANT  MSB14 = 1.865
" CPS14 = Surface Specific Heat (Joules/kg-deg C) "
CONSTANT CPSB14 = 1590.0
" KOB14 = Convective Heat Transfer Coefficient(Watts/mm**2-Deg C) "
CONSTANT KOB14  = 156.45E-6
" Initial Conditions on State Variables "
CONSTANT TIB14Z = 25.0, TSB14Z = 25.0  $" Deg C "
" TOB14 = Outside Air Temperature "
CONSTANT TOB14 = 25.0                        $" Deg C "
                " Initial Region Computations "
INITIAL
" Thermal model Computed Parameters "
" CTHIB14= Battery Interior Thermal Capacitance (Watt-Sec/deg C) "
CTHIB14  = MACID*CPACID+MLEAD*CPLEAD
" RSB14  = Surface Conductive Heat Transfer Resistance(deg C/Watts)"
RSB14    = THKB14/(KSB14*ASB14)
" CTHSB14= Battery Surface Thermal Capacitance (Watt-Sec/deg C) "
CTHSB14  = MSB14*CPSB14
" ROB14  = Surface Convective Heat Transfer Coefficient(deg C/Watts)
ROB14    = 1.0/(KOB14*ASB14)
END INITIAL
 DYNAMIC
  DERIVATIVE EQS
                " Simulation Controls "
  ALGORITHM ISTART = 5, IRUN = 5
  CINTERVAL CI      = 0.5
  NSTEPS    NST    = 500
  MINTERVAL HMINT = 1.0E-20
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"IBB14 = Battery Current(Amps) "
" Positive Current = Charge, Negative Current = Discharge "
IBCB14 = IBB14T(AMOD(T,IBPER14))
IBDB14 = IBB14IN*STEP(TSCELL,T)
PROCEDURAL(IBB14 = T,TSCELL, IBCB14, IBDB14, IMODB14)
  IF(T.LT.TSCELL)   THEN
    IBB14   = 0.0
  ELSEIF(T.GE.TSCELL.AND.IMODB14.LT.0.5)   THEN
    IBB14   = IBCB14
  ELSEIF(T.GE.TSCELL.AND.IMODB14.GT.0.5)   THEN
    IBB14   = IBDB14
  ENDIF
END
" Compute Resistance Correction Factor "
" CFRB14 = Resistance Correction Factor "
CFRB14  = CFRB14T(TIB14)
" Compute Cell Storage Capacity "
" CSB14= Capacitance within Voltage Limits "
CSB14   = CSB14T(IBB14)
" Capacitance outside Voltage Limits "
CSLB14  = CSLB14T(IBB14)
" State equations for the electric analog circuit model "
" Cell-6 Eqs "
IBC6B14  = IBB14
CSC6B14 = CCB14(VC6B14, VCMNB14, VCMXB14, CSB14, CSLB14)
RIC6B14  = CFRB14*RIC6B14I
RLC6B14  = CFRB14*RLC6B14I
ILC6B14  = (VOC6B14/RLC6B14)
VOC6B14, ICC6B14, VOC6B14S, PWLC6B14 = CEQSB14(IBC6B14, ILC6B14,...
                             CSC6B14, VOC6B14Z, RIC6B14, RLC6B14)
VC6B14    = VOC6B14+RIC6B14*IBC6B14
VB6B14    = VC6B14+VB5B14
" Cell-5 Eqs "
IBC5B14  = ICC6B14
CSC5B14  = CCB14(VC5B14, VCMNB14, VCMXB14, CSB14, CSLB14)
RIC5B14  = CFRB14*RIC5B14I
RLC5B14  = CFRB14*RLC5B14I
ILC5B14  = (VOC5B14/RLC5B14)
VOC5B14, ICC5B14, VOC5B14S, PWLC5B14 = CEQSB14( IBC5B14, ILC5B14,..
                             CSC5B14, VOC5B14Z, RIC5B14, RLC5B14
VC5B14    = VOC5B14+RIC5B14*IBC5B14
VB5B14    = VC5B14+VB4B14
" Cell-4 Eqs "
IBC4B14  = ICC5B14
CSC4B14  = CCB14(VC4B14, VCMNB14, VCMXB14, CSB14, CSLB14)
RIC4B14  = CFRB14*RIC4B14I
RLC4B14  = CFRB14*RLC4B14I
ILC4B14  = (VOC4B14/RLC4B14)
VOC4B14, ICC4B14, VOC4B14S, PWLC4B14 = CEQSB14 ( IBC4B14, ILC4B14,.
                             CSC4B14, VOC4B14Z, RIC4B14, RLC4B14
VC4B14    = VOC4B14+RIC4B14*IBC4B14
VB4B14    = VC4B14+VB3B14
" Cell-3 Eqs "
IBC3B14  = ICC4B14
CSC3B14  = CCB14(VC3B14, VCMNB14, VCMXB14, CSB14, CSLB14)
RIC3B14  = CFRB14*RIC3B14I
RLC3B14  = CFRB14*RLC3B14I
ILC3B14  = (VOC3B14/RLC3B14)
VOC3B14, ICC3B14, VOC3B14S, PWLC3B14 = CEQSB14 ( IBC3B14, ILC3B14,.
                             CSC3B14, VOC3B14Z, RIC3B14, RLC3B14
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VC3B14    = VOC3B14+RIC3B14*IBC3B14
VB3B14    = VC3B14+VB2B14
" Cell-2 Eqs "
IBC2B14   = ICC3B14
CSC2B14   = CCB14(VC2B14, VCMNB14, VCMXB14, CSB14, CSLB14)
RIC2B14   = CFRB14*RIC2B14I
RLC2B14   = CFRB14*RLC2B14I
ILC2B14   = (VOC2B14/RLC2B14)
VOC2B14, ICC2B14, VOC2B14S, PWLC2B14 = CEQSB14 ( IBC2B14, ILC2B14,
                                CSC2B14, VOC2B14Z, RIC2B14, RLC2B14
VC2B14    = VOC2B14+RIC2B14*IBC2B14
VB2B14    = VC2B14+VB1B14
" Cell-1 Eqs "
IBC1B14   = ICC2B14
CSC1B14   = CCB14(VC1B14, VCMNB14, VCMXB14, CSB14, CSLB14)
RIC1B14   = CFRB14*RIC1B14I
RLC1B14   = CFRB14*RLC1B14I
ILC1B14   = (VOC1B14/RLC1B14)
VOC1B14, ICC1B14, VOC1B14S, PWLC1B14 = CEQSB14 ( IBC1B14, ILC1B14,
                                CSC1B14, VOC1B14Z, RIC1B14, RLC1B14
VC1B14    = VOC1B14+RIC1B14*IBC1B14
VB1B14    = VC1B14
" VTB14= Battery Terminal Voltage (Volts) "
VTB14     = VB6B14
   " AHB14= Net Battery Ampere-Hour Capacity (AH) "
AHB14S    = (1.0/3600.0)*ICC6B14
AHB14     = INTEG(AHB14S,AHB14Z)
" State Of Charge (SOC) "
SOCB14    = (AHB14/AHB14R)
" Power Computations "
" PWTB14 = Power at the Battery Terminal (Watts) "
PWTB14    = VTB14*IBC6B14
" State Equations for the Thermal Model "
" TIB14S = Rate of Interior Battery Temperature (Deg C/sec)"
" TIB14  = Interior Battery Temperature (Deg C)"
" CTHIB14= Battery Interior Capacitance (Watt-Sec / Deg C) "
" HINB14 = Input Heating Power (Watts) "
HINB14    = PWLC1B14+PWLC2B14+PWLC3B14+PWLC4B14+PWLC5B14+PWLC6B14
" HSB14   = Interor-Surface Conduction Heat Transfer (Watts) "
" TSB14   = Battery Surface Temperature (deg C) "
" RSB14   = Interior-Surface Conduction H-T Coefficient(deg C/Watts
HSB14     = (TIB14-TSB14)/RSB14
TIB14S    = (1.0/CTHIB14)*(HINB14-HSB14)
TIB14     = INTEG(TIB14S,TIB14Z)
" TSB14S = Rate of Battery Surface Temperature (deg C / sec) "
" TSB14   = Battery Surface Temperature (deg C) '
" CTHSB14= Battery Surface Thermal Capacitance (Watt-Sec/deg C ) "
" HOB14   = Surface-to-Outside Convective Heat Transfer (Watts) "
" TOB14   = Outside air Temperature (deg C ) "
" ROB14   = Surface-to-Outside Convective H-T Coefficient(deg C/Wat
HOB14     = (TSB14-TOB14)/ROB14
TSB14S    = (1.0/CTHSB14)*(HSB14-HOB14)
TSB14     = INTEG(TSB14S,TSB14Z)
  END DERIVATIVE
 TERMT(T.GE.TFIN)
 END DYNAMIC
 TERMINAL
 END TERMINAL
END PROGRAM
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